Efficacy of covered stent placement for central venous occlusive disease in hemodialysis patients

Javier E. Anaya-Ayala, MD,[a,b] Christopher J. Smolock, MD,[a] Benjamin D. Colvard, BA,[b] Joseph J. Naoum, MD,[a,b] Jean Bismuth, MD,[a,b] Alan B. Lumsden, MD,[a,b] Mark G. Davies, MD, PhD, MBA,[a,b] and Eric K. Peden, MD,[a,b] *Houston, Tex*

Objectives: **Covered stents have been proposed as an endovascular option for recalcitrant cases of hemodialysis-related central venous occlusive disease (CVOD). This study evaluated the efficacy and durability of covered stents in treating CVOD to preserve a functional dialysis access circuit.**

Methods: **A retrospective review was performed of all patients with clinically significant CVOD who were treated by placement of covered stents from April 2007 to September 2010. Demographics, lesion locations and anatomic characteristics, stent graft, and access patency rates were determined. Complications, reinterventions, and factors influencing their outcomes were examined.**

Results: **In 25 patients (56% men; mean age, 57 ± 29 years) with CVOD, covered stents were used in 20 to treat symptomatic venous hypertension or in 5 at the time of access creation to enable functionality. The target lesion was accessed via the dialysis access site or the common femoral vein. The Viabahn endoprosthesis (W. L. Gore and Associates, Flagstaff, Ariz) was used in 24 patients (average size and length, 11 mm × 5 cm) and a 13-mm × 5-cm Fluency covered stent (Bard Peripheral Vascular, Tempe, Ariz) was implanted in 1 patient. Technical success was 100%, and resolution of arm edema occurred after covered stent deployment in symptomatic patients. Two postprocedural cases (8%) of thrombosis occurred, one within 30 days and another at 3 months. Both required percutaneous thrombectomy and percutaneous transluminal angioplasty (PTA). Three additional patients (12%) required PTA due to restenosis in one of the ends of the device. Covered stent primary patency (PP), assisted primary patency (APP), and secondary patency (SP) were 56%, 86%, and 100% at 12 months, respectively. Access patency rates at 12 months were 29%, 85%, and 94% for PP, APP, and SP, respectively, in patients that received a covered stent for access salvage; patency rates were 74%, 85%, and 94% for PP, APP, and SP, respectively, in patients in whom the access was created after the venous outflow restoration.**

Conclusions: **Placement of covered stents for hemodialysis-related CVOD is safe, effective in relieving symptoms, and enabled functionality of new dialysis access circuits. Further prospective and randomized studies are necessary to determine whether covered stents provide superior long-term results to those achieved with PTA and bare metal stents.**

(J Vasc Surg 2011;54:754-9.)

Central venous occlusive disease (CVOD) remains a significant problem in the long-term management of hemodialysis patients.[1-5] CVOD disrupts the hemodialysis access circuit by causing venous hypertension and access flow dysfunction, with or without debilitating symptoms in the ipsilateral limb.[6] The use of temporary access catheters and lack of an adequate preoperative strategy to select an appropriate access site has resulted in a significant increase of CVOD during the last decade,[6] and the management of this complication is becoming an integral part of vascular practice.[7]

The likely cause of CVOD is the development of venous intimal hyperplasia from chronic trauma caused by repeated catheterization for interim access; in addition, the high-flow turbulent flow from an existing arteriovenous access may contribute to the development of stenosis.[5-9] The optimal approach and treatment for symptomatic CVOD is not well defined. Endovascular techniques are the first-line therapy, whereas open procedures are reserved for when percutaneous modalities fail.[9] However, neither approach has gained acceptance as the standard of care.[10]

In 2006, the National Kidney Foundation (NKF) Disease Outcomes Initiative (KDOQI) guidelines recommended percutaneous transluminal angioplasty (PTA), with or without stent placement, as the preferred intervention.[11] Past studies have suggested that PTA combined with bare-metal stents (BMS) for central venous lesions improves the success with better long-term patency[6]; however, this improvement has not been confirmed. Still, BMSs for CVOD in the setting of refractory stenosis are being used. Until now, no literature has demonstrated the superiority of BMS over PTA.[6]

More recently, covered stents have been used as a treatment option in unmanageable lesions. The potential

From the Department of Cardiovascular Surgery, Methodist DeBakey Heart & Vascular Center[a] and The Methodist Hospital Research Institute,[b] The Methodist Hospital.

Competition of interest: none.

Presented at the Twenty-fourth Annual Meeting of the Eastern Vascular Society, New York, NY, September 30-Oct 2, 2010.

Reprint requests: Eric K. Peden, MD, Department of Cardiovascular Surgery, Methodist DeBakey Heart & Vascular Center, The Methodist Hospital, 6550 Fannin St, Ste 1401, Houston, TX 77030 (e-mail: ekpeden@tmhs.org).

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a competition of interest.

0741-5214/$36.00

doi:10.1016/j.jvs.2011.03.260

advantages of these devices include providing a relative inert and stable intravascular matrix for endothelialization and a barrier for the development of intimal hyperplasia, while providing the mechanical advantages of a BMS.[6] Placement of these devices in the intrathoracic veins has been demonstrated to be a safe and an effective means of controlling bleeding in emergency situations.[12-14] The experience reported for stenotic or occlusive lesions is limited to small series.[11,15-17] The aim of this study was to evaluate the efficacy and durability of covered stents in treating CVOD to restore the venous outflow, preserving a functional arteriovenous (AV) dialysis access circuit.

PATIENTS AND METHODS

Study design. This was a retrospective review of dialysis patients with clinically significant CVOD in whom a covered stent was implanted between March 2007 and September 2010. Hospital and clinic records were reviewed and patients contacted to try to obtain as complete follow-up data as possible. The Institutional Review Board approved this retrospective study.

Study setting. This study took place at a 1000-bed academic medical center, which is a tertiary and quaternary referral facility serving a catchment area of 5 million people. During the study period, 1694 access-related procedures were performed, and 312 of these were access revisions, including endovascular salvages.

Study population. The study included 25 patients (56% men) who were a mean age of 57 ± 29 years. Of these, 20 (80%) had a functioning AV access site ipsilateral to an occluded central vein and symptomatic upper extremity venous hypertension. The indication for covered stent placement was access salvage: 17 patients had native AV fistulas (AVFs) and 3 had AV grafts (AVGs). The remaining five patients (20%) required new access creation, and during the preoperative evaluation, were discovered to have central occlusions bilaterally or unilaterally along with inadequate or exhausted peripheral veins for new access in the contralateral limb. The lesions in all five patients were resistant to angioplasty. After the successful deployment of the covered stent, four AVFs and one AVG were created.

Patient demographics, comorbidities, and indications for covered stent placement are listed in (Table I). All patients had undergone multiple central venous catheter placements. Each underwent upper extremity and central venography, and only those patients with at least one central venous lesion were included. None of these patients had previously undergone open surgical treatment for CVOD. No patients had a history of upper extremity deep venous thrombosis (DVT) or hypercoagulable disorders. Details of the interventions were obtained by a review of the operative notes and venograms.

Definitions. CVOD was defined >50% stenosis of the central venous system, consisting of subclavian vein (SCV), brachiocephalic (BCV), and the superior vena cava (SVC).

Patency rates were defined according to the Committee on Reporting Standards for Arterio-Venous Accesses of the Society for Vascular Surgery and American Association for Vascular Surgery.[18] Primary patency was defined as the interval from device implantation to the first intervention; assisted primary patency was the interval from the time of measurement of patency, including intervening manipulations to maintain the functionality of a patent access. Secondary patency or "cumulative patency" was defined as the interval from covered stent implantation to failure, taking into account any interventions performed to maintain patency.

Table I. Patient demographics, medical comorbidities, and indications for covered stent placement

Demographics	*No, (%) or Mean ± SD (range)*
Patient total	25 (100)
Age, years	57 ± 29 (39-86)
Sex	
Male	14 (56)
Female	11 (44)
Medical comorbidities	
Arterial hypertension	22 (88)
Type 2 diabetes mellitus	13 (52)
Coronary artery disease	10 (40)
Peripheral arterial disease	6 (24)
Cerebrovascular accident[a]	6 (24)
Congestive heart failure	3 (12)
Indications for covered stent	
Access salvage[b]	20 (80)
Access creation[c]	5 (20)

SD, Standard deviation.
[a]Stroke or transient ischemic attack.
[b]Salvage of existing access.
[c]Outflow restoration before access creation.

Access failure was defined as an access ipsilateral to the affected central venous segment in which complications developed, such as thrombosis, infection, thrombosis that resulted in ligation, or access removal. Clinical success was defined as resolution of pain, edema with preservation of AV access, or successful AV access creation after the outflow restoration with covered stent placement in the central veins.

The complications included in our analysis were infection, thrombosis, restenosis, and problems with access that influenced functional stent graft patency. Occurrence of events was ascertained during our review of medical records and by follow-up with a phone interview. The outcomes of complications were classified as resolved, meaning the problem was fixed, or not resolved, meaning the problem still existed despite intervention. Reinterventions were classified according to procedure and dates were recorded.

The patients were clinically evaluated at 6 weeks after the intervention, and clinical deterioration prompted repeated venography. The patient's status after discharge was monitored through clinic records, and patients were seen in the clinic and evaluated by duplex ultrasound imaging before the data analysis. Finally, they were contacted to determine access complications since their last visit at our institution. Survival was confirmed by querying the Social Security Death Index (SSDI).

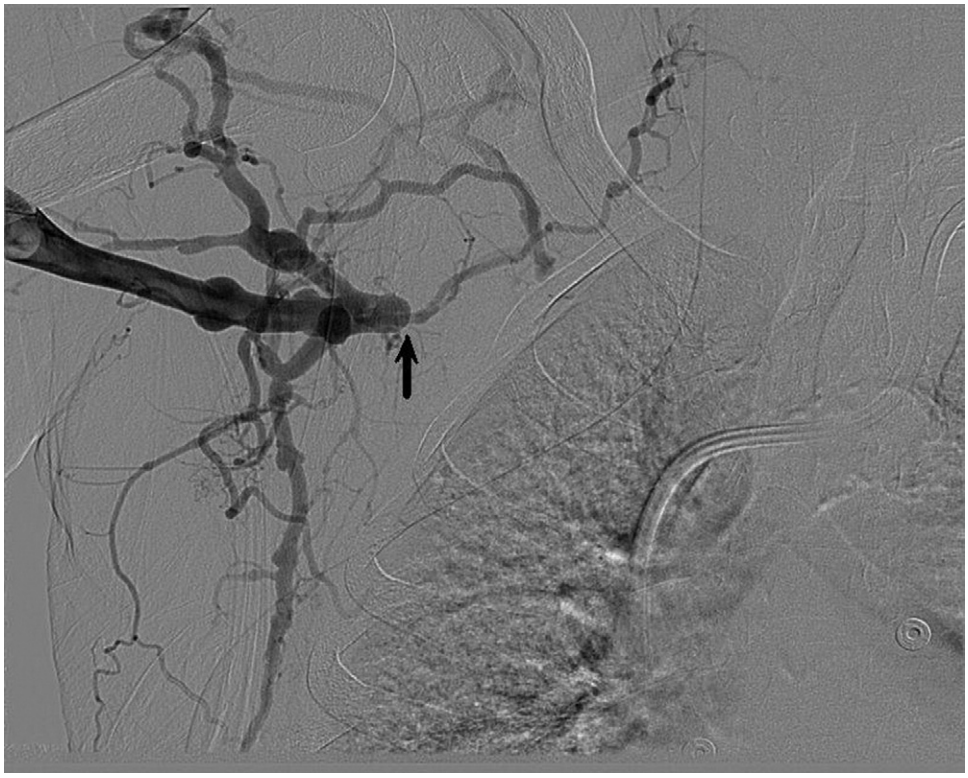

Fig 1. Complete occlusion (*black arrow*) is identified by contrast venography in a patient with severe venous hypertension in the right upper extremity. The lesion consists of a long venous segment from the right axillary to the right brachiocephalic vein, and the presence of multiple collaterals can be also observed.

Technique. The location of the lesion and size of the covered stent used for placement were noted. A single puncture technique was used at the hemodialysis site to enter the venous system in 18 patients. The access in the remaining seven patients was not thought to be adequate to tolerate the large sheath required for delivery of the covered stent, and a femoral vein access site was used.

During the procedure, access was obtained and the central venous stenosis or occlusion identified in venography (Fig 1). The lesions were crossed with a hydrophilic wire that was exchanged for a stiff wire, and balloon angioplasty was performed. Repeat imaging localized the area, and the covered stent was positioned and deployed, with angioplasty repeated. During the course of this series, the platform of the Viabahn endoprosthesis (W. L. Gore and Associates, Flagstaff, Ariz) changed from 0.025 to 0.035 inches, making this procedure much easier with less need for wire exchanges and improved delivery of the covered stent. Technical success was routinely defined as completion venography (Fig 2). Venous pressure measurements were not performed.

We used self-expanding covered stents in all cases, and patients were typically discharged the day of the procedure, after clinical assessment. Patients were assessed during routine follow-up, with clinical success defined as improvement of symptoms and successful dialysis access use in both groups. The response to the covered stent was classified as complete or partial. The duration of the symptom-free period was determined from patient history and physical examination. The AV access was evaluated at each time point.

Statistical analysis. Data were analyzed using JMP 7.0 software (SAS Institute, Cary, NC). Kaplan-Meier analysis was used to estimate primary, assisted primary, and secondary patency according to access service interval. Measured values are reported as percentages or mean ± standard deviation.

RESULTS

Technical success was 100%, and no residual stenosis, defined as >30% stenosis after endovascular management, was observed. Resolution of arm edema occurred in all patients after covered stent deployment in symptomatic patients. Sixteen lesions were localized on the right side. Seven devices were implanted in the right SCV, two in the confluence of the right SCV and BCV, six in the right BCV, and one in the right BCV to the SVC. Nine covered stents were deployed in the left side: four in the left SCV and five in the left BCV (Fig 3). There was no significant difference in laterality of vessels treated.

The Viabahn endoprosthesis was used in 24 patients (average size and length, 11 mm × 5 cm), and 1 patient

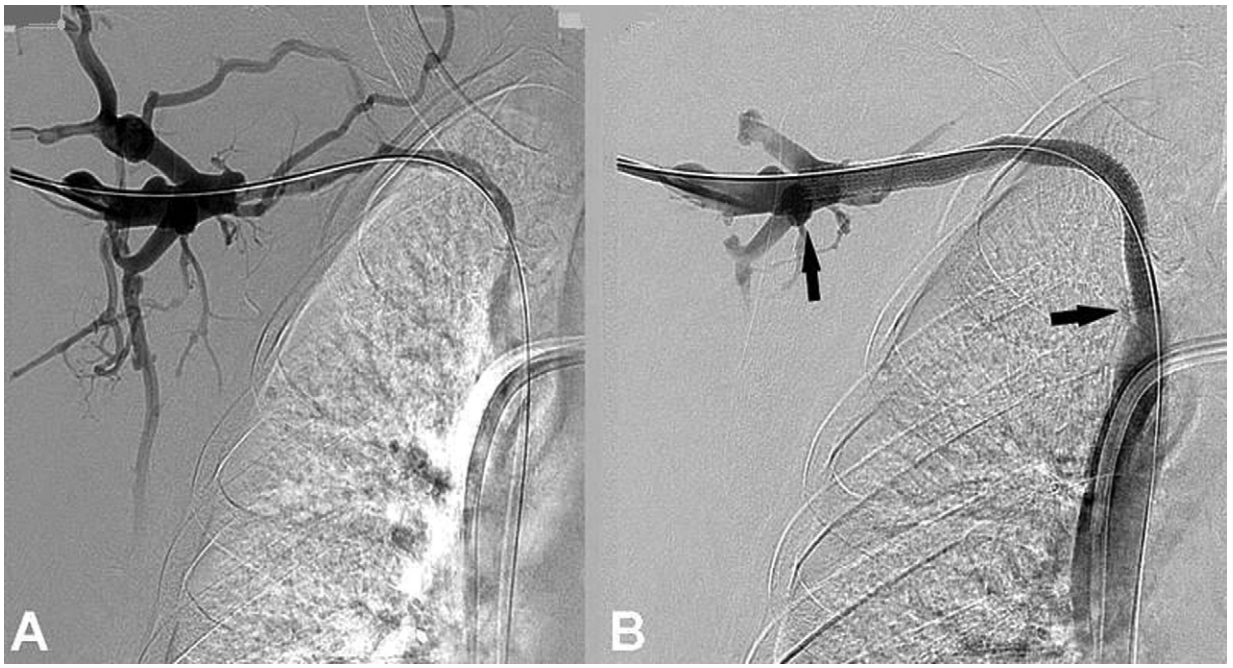

Fig 2. A, The lesion was crossed with a hydrophilic wire, which was exchanged for a stiff wire, and a balloon angioplasty was performed. **B,** Repeat imaging localized the area, and a 150- × 8-mm covered stent was positioned (between two *black arrows*). Contrast injection demonstrates good contour. Immediate resolution of arm swelling occurred after device deployment.

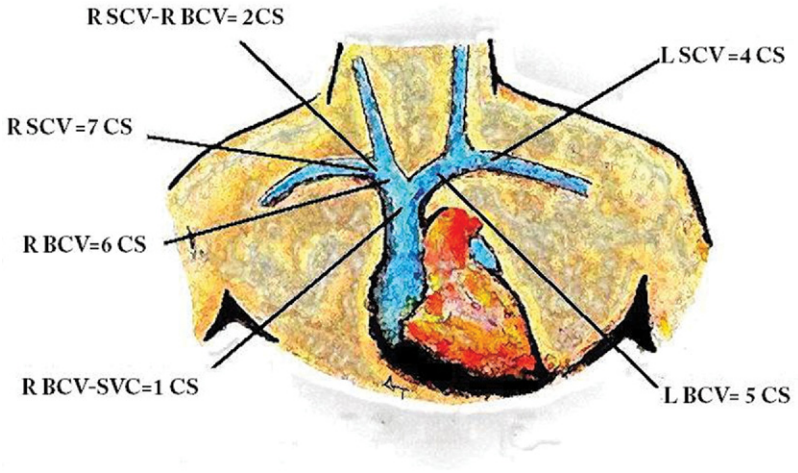

Fig 3. Diagram indicates the number and location of covered stents (*CS*) in the intrathoracic central veins. *BCV,* Brachiocephalic vein; *SCV,* subclavian vein; *SVC,* superior vena cava.

received a 13 mm ×5 cm Fluency (Bard Peripheral Vascular, Tempe, Ariz) covered stent. Device lengths ranged from 5 to 15 cm, and diameters were 8 to 13 mm.

Mean follow-up was 12.4 months (range, 2-29 months), during which two cases (8%) of thrombosis occurred, one within 30 days and another at 3 months. Both patients presented with severe upper extremity edema and access dysfunction, and symptoms resolved after PTA. Three patients (12%) required PTA due to restenosis in one of the ends of the covered stent, which manifested with access dysfunction. Four patients died during the follow-up period of comorbidities nonrelated to the procedure.

The complications and reinterventions occurred in the access salvage group. The lesion location was not predictive of procedural success or failure, and neither immediate nor

Table II. Covered stent and arteriovenous access patency rates at 12 months

Variable	*Patency, %*		
	Primary	*Assisted primary*	*Secondary*
Covered stents	56	86	100
Access patency			
Access salvage	29	85	94
Access creation	74	85	94

delayed migration of the covered stent was identified. No graft infection occurred.

The overall covered stent primary patency (PP), assisted primary patency (APP), and secondary patency (SP) were 56%, 86%, and 100% at 12 months, respectively. In the group that received a covered stent for access salvage, the patency rates at 12 months were PP, 29%; APP, 85%; and SP, 94%. In the group of patients in whom the access was created after the venous outflow restoration with the use of covered stent, patency rates were as follows: PP, 74%; APP, 85%; and SP, 94% (Table II).

DISCUSSION

Nonmalignant CVOD will become a more common problem for the vascular specialist as the dialysis population continues to increase and the use of central venous catheters increases for multiple reasons. Previous studies have indicated that 27% of these patients had previous central vein catheterization;[19] these lesions are more prevalent when catheters are placed through SCVs (42% to 50%) compared with 10% of those placed via the internal jugular vein.[20,21] The use of peripherally inserted catheters and central venous port catheters are also becoming increasingly important risk factors; most of these patients are asymptomatic and symptoms present after a hemodynamic challenge, such as placement of an ipsilateral AV access. In many cases, CVOD is detected on a diagnostic venogram before access creation.[22]

When approaching dialysis patients with CVOD, we find it important to consider other dialysis access options. For patients with a functioning access and venous hypertension, evaluation of the access causing the venous hypertension is integral. For accesses with a volume flow of >1.5 or 2 L/min, consideration should be given to a flow reduction procedure, such as plication or banding of the AV shunt, because the collaterals can often adequately provide outflow from the arm in the setting of a lower volume flow.

Bilateral venography is recommended for patients who will be treated for CVOD. Complete imaging can lead to better planning to ensure complete treatment of the lesion with preservation of other access options (ie, the influence of contralateral central venous patency). The currently approved devices fail to meet the clinical need of treatment of CVOD. Angioplasty has been demonstrated to have poor intermediate-terms results, and BMSs provide an excellent immediate radiographic result, but both have had disappointing durability. The use of the covered stent is an "off label" utilization of this device as an effort to improve clinical efficacy. These dialysis patients with CVOD are some of the most difficult to treat, which prompted us to try the covered stent for this application. Previous reports of covered stenting for this setting are very limited and give no substantial follow-up data, leading us to report our early experience.[17]

Endovascular intervention for hemodialysis-related CVOD remains the present mainstay of treatment. As mentioned, these options include PTA and placement of BMSs. PTA has shown variable technical success of 70% to 90% and variable 6- and 12-month PP rates. BMSs are the second-generation technology and the second-line treatment of CVOD. They provide the mechanical support to a site of stenosis that is resistant to PTA with high technical success (100%) in all reports. BMSs have significant limitations, however, and after the deployment they may migrate, shorten, or fracture at a subacute or delayed stage.[23] The largest series, published in 1999 by Haage et al,[24] included 50 patients in whom 50 Wallstents (Boston Scientific, Natick, Mass) were placed, with a reported 12-month PP of 56%; however, the patency of the BMS in this study was assumed if there was no evidence of access failure.

Covered stents are available in balloon-expandable or self-expanding platforms. In practical terms, a self-expanding platform would be preferred, given the rigidity of the balloon-expandable platforms and potential for crushing of balloon-expandable stents.[7] Covered stents provide an interesting treatment alternative for CVOD because they have had moderate results for central venous stenosis and occlusion in hemodialysis patients, with their use reserved for suboptimal angioplasty or refractory stenosis. In 1996, Sapoval et al[16] mentioned the use of a nitinol plus Dacron-covered stent (Craig Endopro Mintec, La Ciotat, France) for in-stent stenosis of a Wallsent, with asymptomatic recurrent restenosis after 6 months. In a 2003 study, Quinn et al[11] placed six covered stents for venous outflow stenosis. Combined PP rates were 40%, 32%, and 32%, respectively, at 2, 6, and 12 months, and the respective SP rates were 70%, 55%, and 39%.[11]

Our study has some recognized limitations, including a small number of patients and the single-center experience. An interesting question not addressed in this series of cases, is if there is an extrinsic component in the development of hemodialysis-related CVOD. Some investigators of venous thoracic outlet syndrome have suggested different normal anatomic structures and sites as the primary instigators of venous compression and strongly believe that this needs to be addressed before endovascular treatment of CVOD.[25]

In the present series, an extrinsic component was not investigated as the etiology and is a potential shortcoming of any endovascular treatment in this area. We have been sufficiently pleased with our results with covered stents for dialysis-related CVOD that we consider it as a treatment for angioplasty failure as long as other access options are not affected.

CONCLUSIONS

Endovascular therapy with a covered stent for CVOD is safe and effective in hemodialysis patients. In the present series, covered stents demonstrated promising results. Further prospective, and randomized studies are necessary to determine whether covered stents provide superior long-term results to those achieved with PTA and BMS.

The authors thank Nyla Ismail, PhD, and Daynene Vykoukal, PhD, for the critical reading of the manuscript.

AUTHOR CONTRIBUTIONS

Conception and design: EP, MD, JA
Analysis and interpretation: EP, MD, JA
Data collection: JA, CS, BC
Writing the article: JA, EP, MD
Critical revision of the article: AL, JB, JN, EP, MD
Final approval of the article: EP, MD
Statistical analysis: JA, MD, EP
Obtained funding: Not applicable
Overall responsibility: EP

REFERENCES

1. Padberg FT Jr, Calligaro KD, Sidawy AN. Complications of arteriovenous hemodialysis access: recognition and management. J Vasc Surg 2008;48(5 Suppl):55-80S.
2. Sidawy AN, Spergel LM, Besarab A, Allon M, Jennings WC, Padberg FT Jr, et al. The Society for Vascular Surgery: clinical practice guidelines for the surgical placement and maintenance of arteriovenous hemodialysis access. J Vasc Surg 2008;48(5 Suppl):2-25S.
3. Besarb A, Sullivan KL, Ross RP, Moritz MJ. Utility of intra-access pressure monitoring in detecting and correcting venous outlet stenoses prior to thrombosis. Kidney Int 1995;47:1364-73.
4. National Kidney Foundation. Kidney Disease Outcomes and Quality Initiative (K/DOQI), 2006 update. Available at: http://www.kidney.org.
5. Lumsden AB, MacDonald MJ, Isiklar H, Martin LG, Kikeri D, Harker LA, et al. Central venous stenosis in the hemodialysis patient: incidence and efficacy of endovascular treatment. Cardiovasc Surg 1997;5:504-9.
6. Kundu S. Review of central venous disease in hemodialysis patients. J Vasc Interv Radiol 2010;21:963-8.
7. Bakken AM, Protack CD, Saad WE, Lee DE, Waldman DL, Davies MG, et al. Long-term outcomes of primary angioplasty and primary stenting of central venous stenosis in hemodialysis patients. J Vasc Surg 2007;45:776-83.
8. Rueda CA, Nehler MR, Kimball TA, Dimond KR, Whitehill TA, Peyton BD, et al. Arteriovenous fistula construction using femoral vein in the thigh and upper extremity: single-center experience. Ann Vasc Surg 2008;22:806-1.
9. Anaya-Ayala JE, Bellows PH, Ismail N, Cheema ZF, Naoum JJ, Bismuth J, et al. Surgical management of hemodialysis-related central venous occlusive disease: a treatment algorithm. Ann Vasc Surg 2011;25:108-19.
10. Sprouse LR 2nd, Lesar CJ, Meier GH 3rd, Parent FN, Demasi RJ, Gayle RG, et al. Percutaneous treatment of symptomatic central venous stenosis [corrected]. J Vasc Surg 2004;39:578-82.
11. Quinn SF, Kim J, Sheley RC. Transluminally placed endovascular grafts for venous lesions in patients on hemodialysis. Cardiovasc Intervent Radiol 2003;26:365-9.
12. Azizzadeh A, Pham MT, Estrera AL, Coogan SM, Safi HJ. Endovascular repair of an iatrogenic superior vena caval injury: a case report. J Vasc Surg 2007;46:569-71.
13. Burket MW. Challenging cases: superior vena cava rupture. Endovasc Today 2003;2:11-3.
14. Anaya-Ayala JE, Charlton-Ouw KM, Kaiser CL, Peden EK. Successful emergency endovascular treatment for superior vena cava injury. Ann Vasc Surg 2009;23:139-41.
15. Farber A, Barbey MM, Grunert JH, Gmelin E. Access-related venous stenoses and occlusions: treatment with percutaneous transluminal angioplasty and Dacron-covered stents. Cardiovasc Intervent Radiol 1999;22:214-8.
16. Sapoval MR, Turmel-Rodrigues LA, Raynaud AC, Bourquelot P, Rodrigue H, Gaux JC, et al. Cragg covered stents in hemodialysis access: initial and midterm results. J Vasc Interv Radiol 1996;7:335-42.
17. Kundu S. Covered stents for central venous obstruction. 6th Annual Controversies in Dialysis Access. San Francisco, CA, Nov 12-13, 2009.
18. Sidawy AN, Gray R, Besarab A, Henry M, Ascher E, Silva M Jr, et al. Recommended standards for reports dealing with arteriovenous hemodialysis accesses. J Vasc Surg 2002;35:603-10.
19. Agarwal AK, Patel BM, Farhan NJ. Central venous stenosis in hemodialysis patients is a common complication of ipsilateral central vein catheterization. J Am Soc Nephrol 2004;15:368A.
20. Barrett N, Spencer S, McIvor J, Brown EA. Subclavian stenosis: a major complication of subclavian dialysis catheters. Nephrol Dial Transplant 1988;3:423-5.
21. Schillinger F, Schillinger D, Montagnac R, Milcent T. Post catheterization venous stenosis in hemodialysis: comparative angiographic study of 50 subclavian and 50 internal jugular access. Nephrol Dial Transplant 1991;6:722-4.
22. Clark DD, Albina JE, Chazan JA. Subclavian stenosis and thrombosis: a potential serious complication in chronic hemodialysis patients. Am J Kidney Dis 1990;15:265-8.
23. Verstandig AG, Bloom AI, Sasson T, Haviv YS, Rubinger D. Shortening and migration of Wallstents after stenting of central venous stenoses in hemodialysis patients. Cardiovasc Intervent Radiol 2003;26:58-64.
24. Haage P, Vorwerk D, Piroth W, Schuermann K, Guenther RW. Treatment of hemodialysis-related central venous stenosis or occlusion: results of primary Wallstent placement and follow-up in 50 patients. Radiology 1999;212:175-80.
25. Molina JE. A new surgical approach to the innominate and subclavian vein. J Vasc Surg 1998;27:576-81.

Submitted Jan 14, 2011; accepted Mar 18, 2011.